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Material - Corrodents and Corrosion Products - Solid Rocket Propellant Residues

Composition and Removal

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Abstract

Solid propellant combustion products resulting from firing 2.5 inch rockets from F-102 airplanes were found to consist of carbon, various organic materials, and magnesium or magnesium oxide. Twenty-nine materials were tested to determine their effectivity in removing heavy combustion product deposits. Three of these materials, Rocket Cleaners X2-6, X2-9 and X2-11, manufactured by Rocket Chemical Company, San Diego, California, were found suitable for effective and thorough combustion product removal.

Reference: Kruse, G. N., Keller, E. E., Sutherland, W. M., "Chemical Analysis and Removal of Solid Rocket Propellant Residues," General Dynamics/Convair Report MP 59-204, San Diego, California, 2 November 1959. (Reference attached).

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A DIVISION OF GENERAL DYNAMICS CORPORATION
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STRUCTURES-MATERIALS LABORATORIES

REPORT MP-59-204
DATE 2 November 1959
MODEL F-102

TITLE

REPORT NO. MP-59-204

CHEMICAL ANALYSIS AND REMOVAL

OF

SOLID ROCKET PROPELLANT RESIDUES

MODEL F-102

CONTRACT NO. AF 33(600)-33695

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Report No. MP-59-204 Chemical Analysis and Removal of Solid Rocket Propellant Residues - F102

INTRODUCTION:

Firing of the 2.5 in. rockets from the doors of the F-102 results in deposits of solid propellant combustion products being formed in the rocket tubes, on the tube doors which contain the firing mechanism, and on adjacent areas of the fuselage.

As these deposits accumulate, the bore of the tube becomes smaller until this becomes hazardous. In the presence of moisture the deposits become electrically conducting, causing electrical insulators in the firing mechanism to have a low resistance. This electrolyte could also cause excessive corrosion.

OBJECT:

A. To chemically analyze the solid rocket propellant residues resulting from the firing of rockets from the doors of F102 aircraft.

B. To develop and test a suitable cleaner to remove the rocket residues from the rocket tubes and firing mechanism.

CONCLUSIONS:

A. The rocket residues are composed primarily of carbon, various organic materials, and magnesium, and/or magnesium oxide.

B. The cleaners judged to be the most effective are listed in Table III.

RECOMMENDATIONS:

Before any of the solutions,which are effective in removing the rocket residue, are tested on service aircraft, further qualification and development testing should be conducted, to insure that the cleaners are not injurious to metal, finish, or worker.

TEST SPECIMENS:

Rocket Blast Doors (Part No. 8-54598), heavily coated with a burned-on rocket residue, were furnished by the Service Engineering Group for testing. The doors were fabricated from 7075S and 2024S aluminum alloys with firing pins of stainless steel. The gaskets insulating the firing pins from the rocket were made from Teflon.

PROCEDURE & RESULTS:

A. Analysis of Residue

Qualitative spectrographic analysis indicated the presence of magnesium, aluminum and copper with traces of tin, iron, silver, cadmium, lead and zinc.

Qualitative chemical analysis indicated the presence of carbon. Quantitative chemical analysis of the residue for magnesium indicated 4.5% magnesium.

The residue, which undoubtedly, is a mixture of decomposition products of the initial solid propellant, showed a well defined infrared spectrum. A sharp absorption at $2080 cm^{-1}$ indicated the presence of an azide group as this absorption is most probably due to the stretching frequency of -N=N=N-. The sample also showed an absorption at $2175 cm^{-1}$ which is most probably attributed to an alkyl isonitrile and possibly an ethyl isonitrile group of the structure $C_2H_5-N\equiv C$. These two sharp absorption bands appeared to be the most readily identified and most meaningful.

B. Cleaners for Removing Residue

A cleaner for the rocket residue should meet the following specifications:

1. Remove residue with minimum concentration.
2. Have pour point of -65°F or lower.
3. Be relatively non-flammable.
4. Be relatively non-toxic (both vapors and liquid).
5. Not soften finish.
6. Be non-corrosive to aluminum or steel.
7. Evaporate in air leaving little or no residue which would be conductive with moisture.
8. Non-conductive in liquid phase.
9. Rinse off with minimum of other solvents.
10. Not to be too expensive.

To test the effectiveness of various cleaning materials, the following screening tests were used.

1. Removal of Residue

The cleaner was placed on the specimen by means of a stirring rod and allowed to remain for a maximum of five minutes and then was removed by wiping the specimen with a piece of cheesecloth. Results of these tests and the names of cleaning materials evaluated are listed in Table I.

PROCEDURE & RESULTS: (Continued)

B. Cleaners for Removing Residue (Cont'd)

2. Low Temperature Tests

About 150 ml of the cleaner being tested was placed in a 250 ml beaker and submerged in an isopropyl alcohol and dry ice bath. A calibrated thermometer was placed in the cleaner to measure the temperature of the cleaner. The cleaner was observed for viscosity changes, precipitation or solidification. Only those materials which readily removed the rocket residues were tested for their low temperature properties. Test results are listed in Table II.

3. Electrical Conductivity Properties

The cleaner being tested was placed in a conductivity cell rinsed with the cleaner. The electrodes were placed in the solution and allowed to remain for two minutes before the readings were taken. An ohmmeter was used to read the ohms of resistance of the cell. Test results are listed in Table III. The results tabulated are only comparative in showing the differences between the various cleaners.

NOTE: Data from which this report was prepared are recorded in Materials & Processes Laboratory Notebooks, Nos. 3022, 3037 and 3047.

TABLE I

	Cleaner	Results
1.	1 gram chromic acid dissolved in 100 ml alcohol	No cleaning action
2.	3 grams citric acid dissolved in 100 ml alcohol	" " "
3.	20 ml glacial acetic acid in 80 ml trichoroethylene	Removed residue with rubbing
4.	WD-40, manufactured by Rocket Chemical Co., San Diego	No cleaning action
5.	Oakite Composition #56	" " "
6.	Oakite Composition #117, manufactured by Oakite Products Co., New York 6, New York	" " "
7.	5 grams Phenol dissolved in 100 ml alcohol	Slight action on surface
8.	20 ml glacial acetic in 80 ml alcohol	Removed surface residue
9.	TEC 807-12) manufactured by TEC Chemical Co.	Slightly removed residue with hard rubbing.
10.	TEC 901-D) 524-S. Monterey Pass Road, Monterey Park, Calif.	
11.	Rocket Cleaner x2-6)	All three products removed residue effectively and completely.
12.	Rocket Cleaner x2-11) manufactured by Rocket Chemical Company, San Diego, California	
13.	Rocket Cleaner x2-9)	
14.	Carbon Disulfide	No effect
15.	Methylene Chloride	" "
16.	Triethanolamine	" "
17.	Hydrogen Peroxide	Soften surface of residue
18.	Napthenic Acid	No effect
19.	Benzoic Acid in Alcohol	" "
20.	Aminoacetic Acid in Alcohol	" "

TABLE I (Continued)

	Cleaner	Results
21.	Butyl Alcohol	No effect
22.	Ethylene Formate	Soften surface of residue
23.	Aceto Acetic Ester	Soften surface of residue
24.	5% Phosporic Acid in Alcohol	Soften surface of residue
25.	10% " " " "	Soften surface of residue
26.	20% " " " "	Removed surface of residue
27.	5% " " " Iso Propyl Alcohol	Softened surface of residue
28.	10% " " " " " "	Softened surface of residue
29.	20% " " " " " "	Removed surface of residue

The alcohol used was a denatured alcohol composed of 95% Ethanol and 5% Methanol unless otherwise specified.

TABLE II
LOW TEMPERATURE TESTS

Only those mixtures that removed the residue were tested.

Cleaner	Viscosity at -54°C (-65°F)
20 ml Glacial Acetic Acid in 80 ml alcohol	It pours freely - not viscous
TEC-807-12	White precipitate formed on bottom and sides of beakers at -30°C(-22°F)
TEC-901D	White precipitate formed at -45°C (-49°F)
Rocket x2-6	Will pour at -54°C (-65°F)
Rocket x2-9	Will pour at -54°C (-65°F)
Rocket x2-11	Will pour at -54°C (-65°F) *
20 ml Glacial Acetic Acid in Trichloroethylene	Thickened at -25°F.

* The least viscous of the three rocket products.

RESULTS:

TABLE III

ELECTRICAL CONDUCTIVITY PROPERTIES

The electrical resistances were as follow:

20 ml Glacial Acetic Acid in 80 ml Denatured Alcohol	3.5×10^5 ohms
Denatured Alcohol*	4.8×10^6 ohms
Rocket Cleaner X2-6	1.5×10^3 ohms
Rocket Cleaner X2-9	1.8×10^3 ohms
Rocket Cleaner X2-11	1.9×10^3 ohms

* Alcohol by itself was not effective as a cleaner but was tested and included as a reference for measuring conductivity.